Project Summary

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Temporary Measure to Improve the Surficial Stability of Levees by Use of Geocomposite Drainage Systems

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Purpose: To describe a temporary measure for stabilizing and preventing surficial slides on levee slopes by the use of geocomposite drainage systems.

Reference: Use of Geocomposite Drainage Systems as a Temporary Measure to Improve the Surficial Stability of Levees. Dov Leshchinsky. Leshchinsky, Inc. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, Oct. 1996. Technical Report REMR-GT-24.

Impact: The concepts of the geocomposite drainage system suggest a solution to the problem of sloughing instability of levees. The principal idea consists of rapidly draining the subsurface water that would tend to percolate through the dessicated or cracked zone of the embankment. Two drainage systems are proposed: a thin system and a thick system. Detailed design steps, including the estimation of the required flow capacity of the drainage system, the layout of the system, design of the system utilizing ASTM test methods, and selection of appropriate factors of safety, are presented. An installation procedure is also suggested.

Background: As the plasticity of a compacted clay used for levee construction increases, cracks tend to develop during cycles of long dry spells. During heavy rainfalls that follow the dry spells, -water fills the cracks and fissures. In addition to increasing the hydrostatic forces, the water is slowly absorbed by the clay. The effect of the absorbed water is to increase the unit weight of the clay as well as to decrease its shear strength. These mechanisms result in a simultaneous increase of the slide (driving) forces and decrease of the resisting (shear strength) forces. Furthermore, the cyclic shrink/swell behavior of the cracked clay zone results in a progressive reduction of the shear strength of the clay, perhaps approaching its residual strength. It also results in deepening of the cracked clay zone which may eventually reach a depth of 9 ft or more, especially for clays with a plasticity index greater than 40. The end result may be a sloughing failure following a heavy rainfall. It is believed that fast removal of the runoff water from the interconnected network of cracks could alleviate this surficial instability problem.

<u>Design and Construction Procedures:</u>

Drainage System. The design of a geocomposite drainage system for levees is an iterative or optimization process, in which the effects of various layout configurations are examined. The steps to accomplish this process are detailed in items a through h.

a. Using a plan view of the levee, select the desired layout of the composite drainage system. Estimate the drainage (tributary) area of each drain.

b. Estimate the runoff peak discharge due to a given rainfall event over the drainage area. A simple approach is the "Rational Formula." (Seelye 1960), although numerous methods are available.

c. Select the depth of the drainage system. The depth of the geocomposite drain should extend to the bottom of the cracks.

d. Calculate the required flow rate capacity of the geocomposite drain. This is done by dividing the runoff peak discharge (Step b) by the depth of the geocomposite drain (Step c).

e. Calculate the gradient, i (=h/L) or slope, of the geocomposite drain system.

f. Before selecting a particular geocomposite drainage system that can deliver the required flow rate, the maximum sustained lateral pressure is needed. For levees, the maximum depth of the drain is usually less than about 10 ft, so a value of 10 psi should be sufficient. Note, this value contains a factor of safety of two, assuming the horizontal stress is on the order of one-half the vertical stress.

g. Select a geocomposite drain.

h. Repeat steps a through g to optimize the design of the geocomposite drainage system.

Types of Geocomposite Drains. At least two (generic) types of geocomposite drains are available: sheet (thin) drain and corrugated tubing (thick) drain. Figure 1 is a conceptual illustration of thin and thick drains. The sheet drain is comprised of a stiff polymeric core wrapped by a nonwoven geotextile filter. It should be recognized that, because sheet drains are thin, the possibility exists that a local clog due to excessive compression of the sheet drain may occur. Consequently, a bottom collector pipe is frequently installed at the time of construction. The collector pipe, which is relatively inexpensive, will allow water to bypass the local clog and seep downward to the pipe. Although the collector pipe provides redundancy needed to assume long-term performance of the drain, the water carrying capacity of the collector pipe should be ignored when designing the sheet drain. An alternative drainage system is the corrugated tubing system, which has a much larger flow capacity than the sheet drain system. The corrugated tubing drainage system consists of perforated HDPE pipes, each having a 1-in. diameter, stacked to form 6-, 12-, or 18-in.-high panels. The panel of connected pipes has a stable structure and is wrapped by a nonwoven geotextile filter.

Performance Criteria for the Geocomposite Drain. When selecting the geocomposite drain

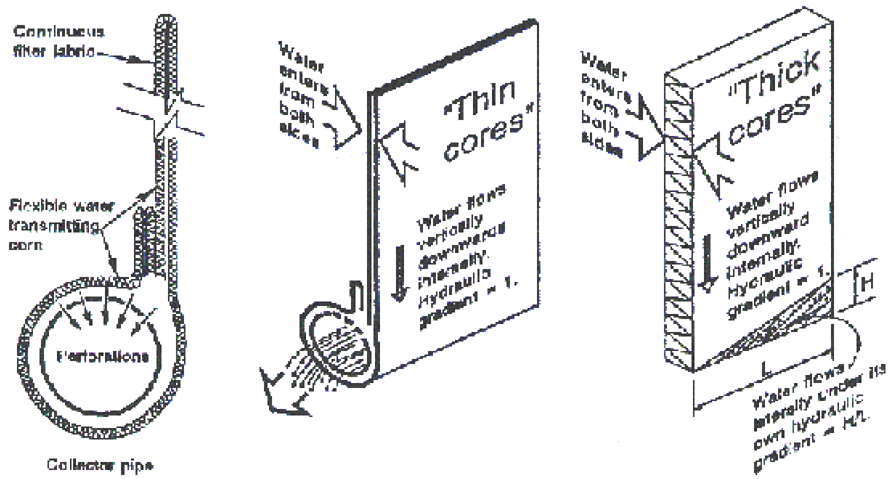

Figure 1. Conceptual illustration of thin and thick geocomposite drains (after Murray and McGowan, 1992).

(Step g), a number of performance criteria should be considered. These criteria follow.

* Select a geocomposite drain that will yield a factor of safety of two to three for the ratio of measured flow capacity (determined according to ASTM D4716) to required flow capacity.

* Conduct the test under a normal (confining) stress of 10 psi (Step f) subjected to gradient i (Step e).

* Conduct the test for a minimum of 14 days to assess potential problems caused by creep of the system.

* Use the steady-state flowrate determined from the test to select the geocomposite drain.

* Determine the short-term compressive strength of the geocomposite drain (ASTM D1621). For levee applications, the compressive (crush) strength should exceed 20 psi.

* Assess the engineering properties of the nonwoven geotextile used in the geocomposite drain.

* To insure installation survivability, the tensile strength should be at least 75 lbs. (ASTM D4632) and the burst strength should exceed 150 psi (ASTM D3786).

* To allow a high rate of flow into the drain system, the permittivity should be greater than

1.0 sec^{-1} (ASTM D4491).

* To prevent a significant amount of clay from being washed into the drain system, the apparent opening size (AOS) should be equivalent to U.S. Standard Sieve No. 70 (0.210 mm) or smaller (ASTM D4751).

* Inspect the nonwoven geotextile to ensure that the synthetic core, i.e., polymeric core or corrugated tubing, is tightly encapsulated.

Construction. The suggested construction scheme is a modification of the one used by Healy and Long (1971). Basically, an unsupported trench is excavated using a trencher. The drain is placed against the upper side of the trench. The excavated soil is then backfilled to just under the top of the drain. Although it is desirable to compact the backfill as it is being replaced, this may not always be possible with an extremely narrow and possibly deep trench.

Limitations: The application of geocomposite drainage systems in levees, as detailed in this report, is new. The proposed utilization of geocomposite drainage systems to improve the surficial stability of levee slopes is based on experience with such systems used for other applications and on sound engineering principles. Until case histories are available to document the performance of the proposed system, the use of geocomposite drainage systems should be considered a temporary measure to improve the surficial stability of levee slopes. A full-scale field test is strongly recommended to assess the effectiveness of using geocomposite drainage systems in levees. Such an experiment will likely lead to improvements in the design and construction techniques suggested herein.

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* D4632, Standard test method for grab breaking load and elongation of geotextiles.
* D4716, Test method for determining the (in-plane) flow rate per unit width and hydraulic transmissivity of a geosynthetic using a constant head.
* D4751, Standard test method for determining apparent opening size of a geotextile.

Volume 07.02.

* D3786, Standard test method for hydraulic bursting strength of knitted goods and nonwoven fabrics - diaphragm bursting strength tester method. (Standard withdrawn September 1996).

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* D1621, Standard test method for compressive properties of rigid cellular plastics.

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